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FERTILIZERS: PHOSPHORIC ACID AND THE MATERIALS SUPPLYING IT.

Phosphoric acid, as spoken of in connection with fertilizers, is made up of the elements phosphorous and oxygen, the latter being a gas, which is present in the air to the extent of about one-fifth of the volume of the air, nitrogen constituting the bulk of the remainder. The element phosphorus—the rest of phosphoric acid—is a soft, yellowish, wax-like solid, which will take fire on a hot day, and in burning unites itself to the oxygen of the air. It is thus that phosphorus could not be used in a free state as a fertilizer, and even after it has united itself to oxygen, the new substance—phosphoric acid—which is formed, is so fond of lime, iron, and similar substances in the soil that the phosphoric acid unites vigorously with them and makes what is known as phosphates. Examples of the latter substances are phosphate of iron and phosphate of lime, the last-named constituting the main portion of bone and the various phosphate rocks. It is not then as phosphorus or phosphoric acid that this important constituent of fertilizers is supplied, but in the combinations indicated as above as phosphates.

Phosphate rock, which is mainly phosphate of lime, is mined in South Carolina, North Carolina (low grade), Florida, Tennessee, and elsewhere. As taken from the mines this rock contains twenty-six to thirty-five per cent of phosphoric acid, which is equal to fifty-six to seventy-seven per cent of phosphate of lime—the remaining portion of the rock being made up of such impurities as sand, clay, limestone and water. As phosphate of lime is the main constituent of bone it is sometimes called bone phosphate. Phosphate of lime or phosphate rock then is the chief source of phosphoric acid in fertilizers.

ACID PHOSPHATE

In its raw or natural state the phosphate has three parts of lime united to the phosphoric acid (called by chemists tri-calcium phosphate). This is very insoluble in water and is not in a condition to be taken up readily by plants. In order to render it soluble in water and fit for plant food, the rock is finely ground and treated with sulphuric acid, which acts upon it in such a way as to take from the three-lime phosphate two parts of its lime, thus leaving only one part of lime united to the phosphoric acid. This one-lime phosphate is what is known as water-soluble phosphoric acid has a tendency to take lime from phosphoric acid. On long standing this water-soluble phosphoric acid has a tendency to take lime from other substances in contact with it, and to become somewhat less soluble. This latter is known as reverted or gone-back phosphoric acid. This is thought to contain two parts of lime in combination with the phosphoric acid and is thus an intermediate product between soluble and the origi-

nal rock. In this treatment some of the ground rock is not acted on by the sulphuric acid and is thus left in its original insoluble condition. This is called insoluble phosphoric acid.

AVAILABLE PHOSPHORIC ACID.

Available phosphoric acid is made up of the water-soluble and reverted; it is the sum of these two; and the available and the insoluble make the total phosphoric acid—it includes all the phosphoric acid present.

As stated above when the ground phosphate rock is treated with sulphuric acid the latter takes from the phosphate two of its three parts of lime. These two parts of lime and the sulphuric acid unite with each other to form what is known as gypsum or land plaster. Acid phosphate then is a mixture of the three forms of phosphoric acid or phosphates referred to above—water-soluble, reverted and insoluble, and gypsum or land-plaster, and water, and the impurities in the original rock—which have been stated to be sand, clay, and oxides of iron and alumina. Were it possible to use pure phosphoric acid in fertilizers (it could not be handled in this state for fertilizer purposes) it would be too costly to separate it from the impurities associated with it in acid phosphate, and nothing would be gained except in freight on the other substances. On this latter account a high-grade acid phosphate is preferable to a low-grade one, as a smaller weight of other materials not specially wanted is present to be freighted and handled. In making acid phosphate ground rock and sulphuric acid are mixed in about equal weights and as a result the acid phosphate produced has only about one-half as much phosphoric acid as the rock from which it was made. South Carolina phosphate rock, containing 26 to 28 per cent of phosphoric acid, will give acid phosphate with 13 to 14 per cent of phosphoric acid, while the acid phosphates from Florida and Tennessee rocks, with 30 to 38 per cent phosphoric acid, contain 15 to 19 per cent phosphoric acid.

Considerable space has been given to the consideration of phosphate rock and to the acid phosphate produced from it, because the latter is the chief source of the phosphoric acid in fertilizers. The forms of phosphoric acid—water-soluble, reverted, and insoluble—have also been dwelt upon, as they have different values as plant food, but the same form is regarded as having the same value, whatever the original source may be. For instance, the water-soluble phosphoric acid from the various phosphate rocks, from bone, from bone-back, etc., are believed to be of equal value regardless of the source of material.

BONE AND BONE MEAL

These were among the early materials used as fertilizers and are still popular and important. "Raw bone," which is usually put on the market as bone meal, contains about 22 per cent of phosphoric acid, which is equal to 48 per cent of phosphate of lime, in which form it is largely present in bone; the remaining 52 per cent of the bone being made up of water, fat and nitrogenous matter in sufficient quantity for the bone to contain about 4 per cent of nitrogen (equal to nearly 5 per cent of ammonia) or eighty pounds in a ton.

The greater portion of the bone put upon the market as "bone meal" has been previously steamed or boiled for the purpose of removing part of the fat nitrogenous materials (glue and gelatine). Fat has no value as a fertilizer and glue and gelatine are worth more as commercial products than for supplying nitrogen in fertilizers. The value of the bone is reduced by this process in proportion to the amount of nitrogen-containing materials removed. Such bone ("steamed") contains from 1 1/4 to 2 1/2 per cent of nitrogen and 25 to 30 per cent of phosphoric acid. The removal of the fat and nitrogenous matter leaves a larger amount of phosphoric acid in the resulting bone, which can be ground finer than raw bone before steaming, as there is not so much fleshy matter present to hold the particles together.

A rather small and variable portion of the phosphoric acid of bone meal is available (soluble), but it becomes available as the bone decomposes—the rate of decay being largely influenced by the fineness of the particles. The availability of the nitrogen of bone will also depend on how fast it decomposes in the soil, the finer the state of division the quicker it will act. From this it will be concluded that bone meal is not a quick acting fertilizer and is not desirable where a quick fertilizer is wanted, but is a good source of nitrogen and phosphoric acid for lawns, permanent grass lands, and long-growing crops.

DISSOLVED BONE

Bone meal is sometimes treated with sulphuric acid, when it is called "dissolved bone." When real bone has been used for this purpose the product contains 2 to 3 per cent of nitrogen and 12 to 15 per cent of available phosphoric acid. Frequently, however, ordinary acid phosphate made from phosphate rock is misnamed "dissolved bone." If the material does not contain nitrogen it may be concluded at once that it was made from phosphate rock and is nothing but an ordinary acid phosphate. Even if it is made from real bone, no more should be paid for the available phosphoric acid in it, as the available phosphoric acid in dissolved bone and acid phosphate are of equal value, but the nitrogen in dissolved bone should be valued in addition to the available phosphoric acid.

Old bones, bleached and white by long exposure, and which have lost all their nitrogen by the decay of the organic matter in them, are worth no more than raw phosphate rock.

Tankage, as stated under nitrogen, contains, in addition to nitrogen, variable amounts of phosphoric acid. There are five or six grades of this material on the market having from 7 to 20 per cent of phosphoric acid, which is equal to 15 to 40 per cent phosphate of lime. The phosphoric acid in tankage is derived from bone and the discussion of its value under bone meal is applicable here. It will be observed that a high nitrogen content in tankage, as with bone meal, means also a correspondingly low phosphoric acid percentage, and that when the nitrogen is low the phosphoric acid is high. It may be well to state that a higher percentage of nitrogen in tankage and bones means a correspondingly large amount of nitrogenous organic matter to decompose, which has a tendency to make the phosphoric acid associated with it available.

Fish scrap has already been stated to contain 6 to 8 per cent phosphoric acid in addition to its 7 to 9 per cent of nitrogen. This phosphoric acid is present in the bones of the fish mainly and one-half to two-thirds is available or will likely become so during a growing season. Fish residues from canneries and packing establishments, which is composed mainly of the offal, skin, and bones, will have more phosphoric acid than ordinary fish scrap from oil establishments, but the latter will have the higher nitrogen content.

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